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ABSTRACT

Part of the Understanding Our Environment project that is designed to engage students in investigating specific environmental problems through concrete activities and direct experience, this unit introduces students to the idea of natural resources and focuses on resources found on land: minerals such as hematite and gypsum; rocks such as granite and limestone; fossil fuels such as natural gas, coal and oil; and surface deposits such as soil, sand, and gravel. Students study characteristics of natural resources and sources of human-made materials, and learn how use of natural resources affects the environment. Objectives include: learning what types of materials, both natural and made by humans, are in the local environment; understanding how the land's natural mineral resources are identified, obtained, and used by humans; finding out the origin, composition, and sources of the materials in our environment; studying the development of landscape and special properties of soil; and considering what people can do about environmental damage caused when humans obtain natural resources from the land. (JRH)

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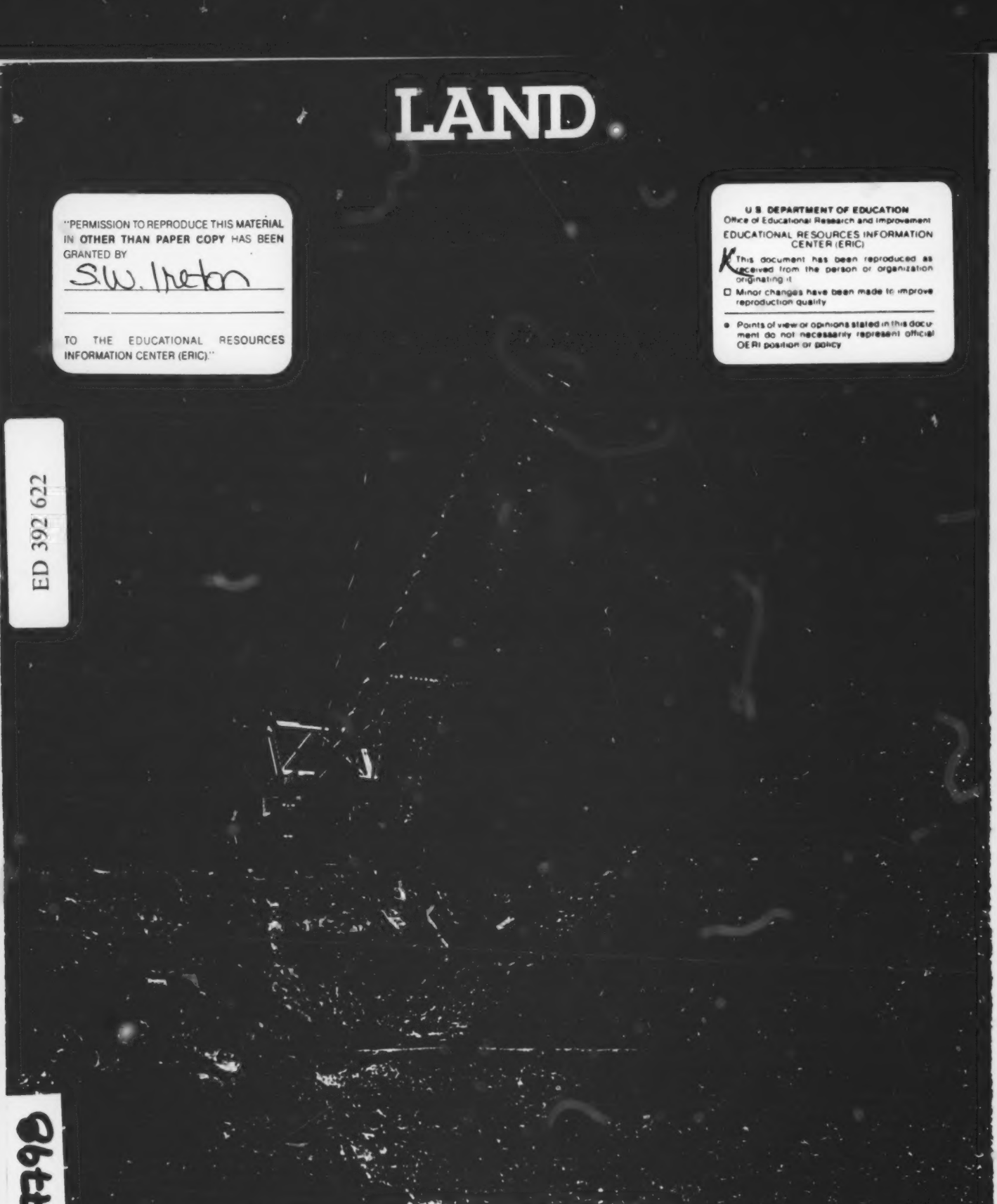

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LAND

Jeffrey C. Callister
and
Janet Wert Crampton

This publication is dedicated to Dr. Alan L. McClelland for his many years of devoted work at DuPont, in the government, and in the community to develop and educate people of all ages in mathematics, engineering, and chemistry. His commitment to advancing the understanding of the sciences has influenced thousands of lives and careers around the world.

Credits

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Portions of this material are based upon *Understanding Our Environment,* DuPont/Conoco, Birmingham, England, 1991. Substantial new material has been added.

Envelope contents for this unit:

Transparencies	*A Soil Profile.* *A Soil Ecosystem.*

Cover: Photograph of the Burning Star 2 Surface Coal Mine, Pinkneyville, IL. Bituminous coal. Most electricity is produced by burning bituminous coal.

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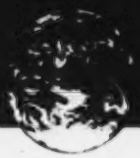


What Are We Doing to Our Land?

Almost all materials and forms of energy humans need to survive and flourish are obtained from resources that we find between a few kilometers above and below Earth's surface—from land, water, air, and living things.

In this unit, students are introduced to the idea of natural resources and focus on resources found on land—minerals like hematite and gypsum, rocks like granite and limestone, fossil fuels like natural gas, coal and oil, and surface deposits like soil, sand, and gravel. Students study characteristics of natural resources and sources of human-made materials, and learn how use of natural resources affects the environment.

In the project, students investigate in detail the different natural resources that make up the landscape and objects at a site they can see from a window, record the information they collect on a large chart. As they learn about minerals, rocks, soil, and the landscape, they record on the chart notes about the minerals, rocks, and soil in the window scene.

Students finish the unit considering land reclamation, energy use, and nonrenewable resources.

Objectives

- Learn what types of materials, natural and made by humans, are in the local environment.
- Understand how the land's natural mineral resources (minerals, rocks, soils, and fossil fuels) are identified, obtained, and used by humans.
- Find out about the origin, composition, and sources of the natural resources that the materials in our environment come from.
- Study the development of landscape and special properties of soil.
- Consider what people can do about environmental damage caused when humans obtain natural resources from the land.

Project: The Window Scene

We depend on resources of air, water, land, and living things for our existence. Most materials we need, use, and enjoy come from resources extracted from or grown on the land or in the ocean.

Students begin their investigation of natural resources by sketching and listing what they can see from a window, then visiting the site of the window scene to collect samples of the materials and objects they find there. Throughout the unit, students learn about the natural resources their collected materials are made from, with an emphasis on those that come from land.

To finish this project, students complete a chart expressing their findings and report on the sources of the materials in the items collected at the site of the window scene. They investigate local soils and the landscape. Finally, they find out about the environmental effects of extracting these resources and consider how they might change their use of the resources so as to change the environmental effects.

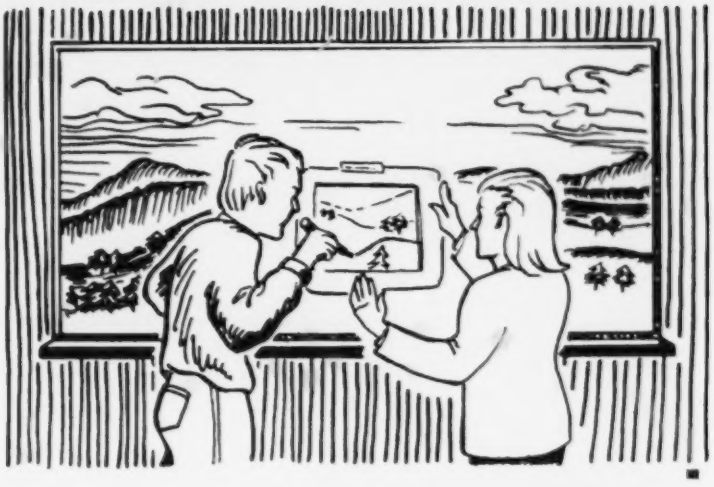
Preliminary Discussion

The two activities that begin the project introduce students to the idea of natural resources. You may wish to begin with a discussion of the term, because the word "natural" is so commonly used in advertising.

A **natural resource** is any natural material that humans use. We drink fresh water, catch fish in the ocean, breathe the air, grow food in soil. Earth's crust contains the mineral and fossil-fuel resources that are the physical foundations of modern life.

Activity: Drawing the Window Scene

Distribute the Activity Sheet "Project: The Window Scene." Have students put blank overhead-projector transparency film in a frame and place it on a window in the classroom or other location. Ask them to draw on the film what they see from the window. (They should use transparency marking pens, which have water-soluble ink, so the drawing can be changed and the film reused.) The



Students draw a window scene.

drawing should include all the objects and parts of the environment they can see.

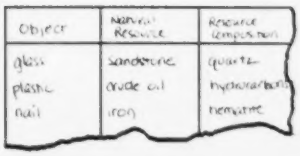
Students should label everything they have drawn. Encourage them to devise a labeling system, such as a numbered or lettered list. Suggest that they put the items in their scenes in categories (landscape elements, atmospheric features, bodies of water, buildings and other human-made objects, and living things, or more specific groupings).

You may wish to photocopy students' window scenes to make them more permanent. Taping a piece of overhead film over the scene will also preserve it.

If you have no appropriate classroom window, you may ask students to make the drawing at home or some other location.

Discussion

After students draw their scene and list what they see, ask them to discuss the parts of the scene—air, water, life, land, and human-made objects. Ask them to think about the natural resources that the human-made objects come from. Some common objects and their main sources are building stone from rock, glass from sandstone, concrete from limestone, steel nails from iron-bearing rocks, plastic from crude oil, and tin in bimetal cans from minerals in igneous rocks or gravel deposits.



The big chart.

The "Big Chart"

Have students begin a big chart, "The Window Scene," with columns headed "Object," "Natural Resource," and "Resource Composition." The objects can be human-made or natural. The column "Resource Location" will be added later. Allow expansion room on the chart. You or the students may want to add other columns.

Students will finish filling out the first two columns after the visit to the window scene. Resource composition will be entered after students have pursued the next activities in this unit.

The composition of the main sources (minerals) of some common objects are quartz for glass, hematite for steel nails, and cassiterite for tin in cans. (Many objects in the scene come from several natural resources. Pencil "lead," for example, is a mixture of graphite and special clays.) Finding the locations of sources will depend on what information students can obtain about the objects.

You may prefer to post window scene information on a bulletin board where columns can be rearranged as information is added. Because this information forms a database, it could be keyed into a computer in an appropriate format.

Information Sources

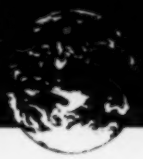
Encourage students to use community, county, state, and national organizations and agencies as information sources. The U.S. Geological Survey Minerals Information Office, the Natural Resources Service of the U.S. Department of Agriculture, the U.S. Bureau of Mines, and state natural resources agencies supply information to the public. You may wish to ask local mineral and rock collectors to talk to the class.

Extension: Minerals Versus Rocks

On the chart of objects in the window scene, add the column "Chemical Formula." Mineral formulas are in field guides and mineralogy textbooks. Formulas for some of the common objects are quartz, SiO_2; hematite, Fe_2O_3; cassiterite, SnO_2. Rocks are usually made of two or more minerals, so they do not have formulas. They are described by color, texture, and composition (see the information sheets about rocks).

Extension: A Database

The chart students make to list all objects from their window scene (natural or human-made), the principal natural resources they come from, composition of the



resources, location of the resources, and other information is a database. The information may be entered in a computer as well as on a chart. Students may develop other databases, such as identification charts for minerals and rocks.

Activity: Visiting the Window Scene

Give out the Activity Sheet "A Visit to the Window Scene." Take students on a field trip to the site of their window scene to complete their drawings and collect samples of the materials and objects they find. If the window scene is inaccessible or dangerous, select another site. You may wish to have students form committees to help plan the field trip.

If the site is on private land, you must obtain permission in writing both to enter and to collect before starting the field trip. Parks have a no-collection policy or require special permission to collect even trash, and often ask for advance notice of visits by groups. Remind students to take only small samples, just enough for the group's work. Overcollecting damages the site for future students.

Students should take their window-scene drawing, the marking pens, water and wiping material to revise their drawings, a grid for mapping, and writing materials to record details of the scene. The aim is to obtain as complete a description of the site as possible.

Safety Note

You may wish students to use disposable plastic gloves when collecting, to protect their hands. If you plan to break rock specimens with hammers, everyone must wear safety goggles for eye protection.

Students should also have labels and plastic bags for collecting samples and objects from the site. Students may take soil samples by digging. Each item taken should be labeled with date and location at the site.

Mapping and Collecting

When you get to the site, ask students how closely their drawings match the real thing. Give them time to revise their drawings, then have them map the site on a grid before they begin collecting.

The technique for mapping a site on a grid, so items can be located, is described in the Water unit. If you have not used the technique before, you may wish to schedule time for the class to practice.

Students may work individually or in small groups. You may wish to divide responsibility at the site: left, center, and right areas, for example, or drawing, describing, mapping, collecting.

Data for the Big Chart

After the field trip students should complete the first two columns of "The Window Scene" chart, listing all the objects in the scene, natural or human-made, and the natural resources they came from. Some objects may be natural resources just as they are.

Extension: Technology Connection

Students may photograph or videotape the site of the window scene, tape-record their observations, or transcribe their notes and the site map to a computer.

Extension: Window Scene Display

Students may assemble a master "window scene" for a hall display or bulletin board. They should include some actual objects from the scene, examples of the natural resources from which these items are made, and an oriented map showing site location.

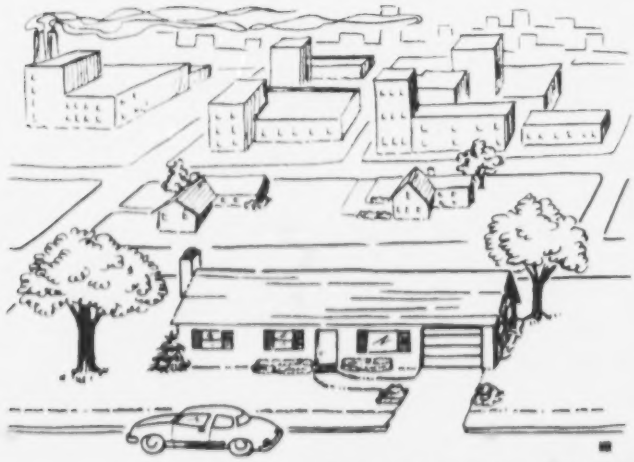
	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										

A grid. See example in Water unit.

Project: The Window Scene

Almost all materials and forms of energy humans need to survive and flourish are obtained from resources we find in a zone ranging from a few kilometers above to a few kilometers below Earth's surface—from land, fresh water, the ocean, air, and living things. In this unit, you will focus on the land as a source of the objects and materials in the world around you. You will learn some characteristics of natural resources and find out how human exploitation of resources affects the environment.

To begin this activity, you will draw and list what you see from a window. You will work individually or in small groups. Your teacher will ask you to use a classroom window, or a window at some other place. After your class has discussed the window scene, you will visit the location or a similar one on a field trip.



An urban window scene.

Drawing the Window Scene

From your window, you see an environment made up of natural and human-made components. Draw this scene and list what you see. The class will talk about the natural resources that the human-made items came from. Later, you will learn about the natural materials and landscape.

Materials

- Transparency film for overhead projectors
- Frames for overhead transparency film
- Transparency marking pens, with water-soluble ink
- Water and wiper to revise your drawing

Procedure

1. Mount the blank overhead film in a frame, as shown by your teacher, and place it on a window in the classroom or other location.

2. Draw on the film what you see through the window. Include all the objects and parts of the environment you can see, in as much detail as possible.
3. Label everything in your picture. You may wish to use a labeling system, such as a numbered or lettered list.
4. Group the items in your list in categories: landscape elements, bodies of water, atmospheric features, living things, and buildings and other human-made objects.
5. Start a large chart, "The Window Scene," with columns headed "Object," "Natural Resource," and "Resource Composition." (The objects you list can be human-made or natural.) Leave room for additional columns.
6. Begin entering information in the first two columns. When you learn more about identifying minerals and rocks as a way of identifying natural resources, you will enter data in the third column. (Some objects in the scene, such as a pencil, will probably come from several natural resources.)

Questions

1. How much of the window scene appears to be human-made?
2. How do you think the human-made objects arrived at the site?
3. What materials do you think the human-made objects are made from? What are the natural sources of these materials?
4. How would you find out more about the resources used to make the objects in your window?

A rural window scene.

A Visit to the Window Scene

Your teacher will go with you on a field trip to the site of your window scene or another suitable location. You will collect samples of many of the things you drew and other items you find there.

Materials

Safety Note

Use gloves when collecting, to protect your hands. If anyone will be breaking rocks with hammers, everyone must wear safety goggles.

- Drawing of the window scene
- Transparency marking pens, with water-soluble ink
- Water and wiper, to revise your drawing
- Grid for mapping the site
- Paper and pencil for writing
- Plastic bags for collecting
- Labels to put on or in bags
- Shovel, trowel, or spoon for taking soil samples
- Hammer (optional)

Procedure

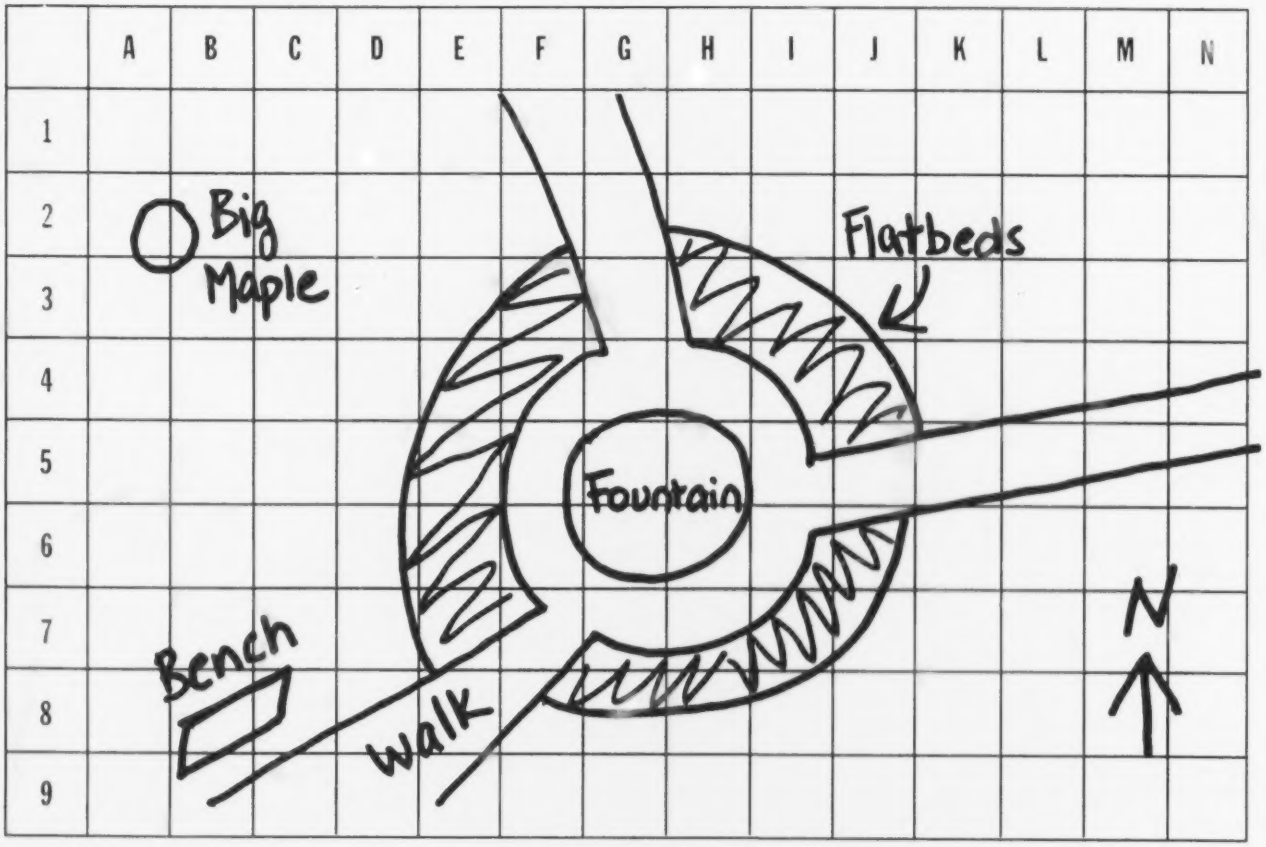
You will be working individually or in groups to revise your drawing and to write a detailed description of the scene. Make a complete list of what you find. Map the scene on a grid (as in the example below), and collect samples if collecting is permitted. Your teacher will tell you which part of the site to work on.

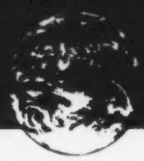
When you return to class, complete the first two columns of the big chart you started for your window scene.

Questions

1. How different is the real site from what you were able to see from the window?
2. How much human influence did you find at the site?
3. Is the extent of human influence different from what you estimated when you looked out the window? If so, how is it different?

Example of a Grid System





Minerals and Natural Resources

Natural resources we use are not evenly distributed around Earth, particularly mineral resources. The mineral resources used in human-made objects collected from the window scene may have come from many different places.

To identify mineral resources, we need to know what we are looking for and how to look for it. The "how to" part changes rapidly as new scientific ideas and new technology enlarge our views of Earth.

The "what" of mineral resources is a rich body of knowledge about minerals and rocks that has ancient origins. The search for rock for special uses like spear points, for salt, for gold and other metals, and for precious stones stretches back into human prehistory, and the desire for mineral resources has caused war, conquest, and settlement. The names for stages of human history—Stone Age, Copper Age, Bronze Age, Iron Age, Steel Age, Silicon Age—show the importance of mineral resources.

In the next two activities, students practice identifying minerals and (in the next section) rocks, to see how people have learned to identify mineral resources. They then apply their new knowledge to the samples they collected at the site of the window scene, or to other appropriate objects.

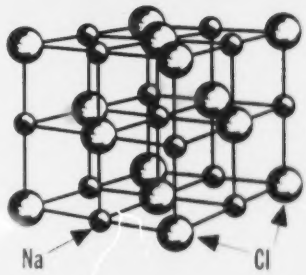
At some sites students may find several kinds of minerals or rocks. Other sites may be agricultural and have only soil or may be almost entirely human-made. You may wish to use commercially prepared mineral and rock sets or ask students to bring minerals and rocks of their own.

What Is a Mineral?

A **mineral** is a naturally occurring, inorganic solid with crystalline structure, a definite chemical composition, and characteristic properties. The main physical properties that help people identify minerals are luster, streak, hardness, cleavage, and color. These and other properties, such as specific gravity, fracture, transparency, tenacity, magnetism, and reaction to acid, are determined by a mineral's chemical composition and crystal structure.

Crystal structure is produced by the orderly internal arrangement of atoms that form a mineral. It is an important identifying property, but many minerals grow as clusters or are spread through rock as small blobs and don't show crystal shape.

Chemical tests can also help identify minerals. If you choose to do some, follow all directions and take safety precautions.

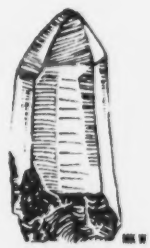


Atomic structure of halite (common table salt, NaCl). Large spheres are chlorine (Cl) ions; small spheres are sodium (Na) ions. Halite forms cubic crystals and cleavage fragments.

Before You Begin

You may wish to lead a class discussion about identification and classification to prepare for mineral identification. Students may already be familiar with identification keys like those for trees or flowers, and may even know how to identify minerals. Procedures for identifying minerals are found in rock and mineral field guides and in geology and mineralogy textbooks and laboratory manuals.

Before the activity, have students prepare charts to record the properties they will observe in mineral specimens. (They might also set up databases in computers.) Students may work alone or in groups. You may wish students to lay out newspaper or other surface covering before they start. Broken mineral and rock pieces, and mineral powder produced on unglazed tiles in a streak test can damage nearly any surface.



Quartz (SiO_2) crystal. Quartz forms hexagonal crystals and has no cleavage.

Suggested Teaching Techniques

Students may benefit from seeing examples of mineral properties before they start their own work. Eight such examples are described by Carol J. Stadum in "Geology Demonstrations on an Overhead Projector," *Journal of Geological Education, 40* (3), May 1992, p. 215.

A cooperative teaching approach in which each group becomes "expert" on selected minerals and presents its study results to the class may work well in this activity. Teacher Terri Lynn Constantopoulos describes her approach in "A Cooperative Approach to Teaching Mineral Identification,"*Journal of Geological Education, 42* (3), May 1994, 261-263.

Safety Note

- Students and teachers must wear safety goggles while breaking samples and identifying minerals with acid.
- Be careful with knives or nails used in hardness tests and of sharp points and edges on the mineral pieces, glass plates, and the unglazed tiles used for streak tests.
- Do not allow students to taste any mineral specimen, even though mineral identification guides list taste as a property that can identify some minerals.

Activity: Identifying Minerals

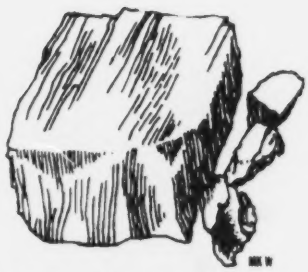
Distribute the Activity Sheets and give students minerals to identify. Begin by looking at **luster**, or the way a surface reflects light, to separate metallic from nonmetallic minerals.

Divide the nonmetallic minerals into light- and dark-colored groups. Then determine hardness, cleavage, and streak for all the minerals.

Halite (rock salt) fragments. Halite's cubic cleavage is related to its crystal structure. The three cleavage directions are at right angles to each other.

Hardness is a comparative property. A mineral has a certain hardness relative to other minerals. Using the Mohs' scale (printed on the Activity Sheet "Identifying Minerals") hardness can be determined with common objects. Your fingernail has a hardness of about 2.5, for example. Diamond is many times harder than other minerals.

When a mineral breaks, planes of weakness in crystal structure appear as flat, parallel **cleavage** surfaces. Help students understand the difference between cleavage, which appears in broken fragments of the mineral, and crystal structure, which shows a mineral's internal atomic arrangement. Some minerals have poor or no cleavage and, instead, **fracture** when broken. (Fracture surfaces are not flat or parallel.) All minerals have crystal structure, although it may not be visible. Quartz, the most common of all minerals, has no cleavage (it has chonchoidal fracture), yet is often found as crystals.



Orthoclase feldspar (potassium aluminum silicate, $KAlSi_3O_8$) has two prominent cleavage directions that are at right angles. In the third direction, the feldspar fractures.

The mineral **color** that you see is not necessarily its **streak** (color of the powdered mineral). Many-colored opal, the October birthstone, has a colorless streak. Shiny metallic minerals like brass-colored pyrite (fool's gold) or silver-colored galena (lead sulfide) often have gray-green or black streaks.

Determining luster, color, hardness, cleavage, and streak should give students enough information to identify most minerals. Learning about other mineral properties, such as magnetism for some iron ores or reaction to acid for the carbonates like calcite, will increase their understanding of mineral identification.

You may wish students to learn about more minerals. Optional materials for testing other mineral properties like specific gravity, tenacity (resistance to breakage),

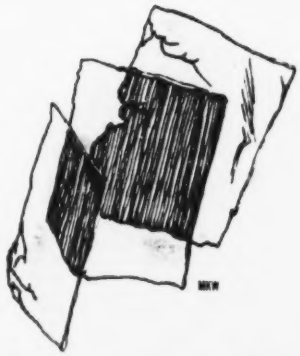
magnetism, fluorescence, and radioactivity are a balance, beakers or jars, small magnets, vinegar or dilute hydrochloric acid, an ultraviolet lamp, and a Geiger counter.

Extension: My Birthstone

Students enjoy researching their birthstones. You may have students work in groups by their birth month. Groups could prepare posters for class presentation and possible hall display. Local mineral collectors or jewelers may be good resources.

Most birthstones are minerals. On their posters students should describe all the mineral properties of their birthstone, including its chemical composition and the chemical reason for its color. They should list its sources and locate them on a map.

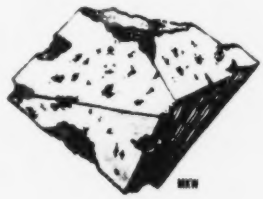
Many fictional stories and historical events feature gem minerals. In connection with literature, history, and social studies classes, students could summarize or dramatize famous stories or incidents about their birthstones or other gems, or write their own stories.



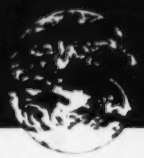
Mica (a mineral group made of hydrous aluminum silicate with potassium, magnesium, or iron) has one excellent cleavage direction.

Extension: Community Connection

You may wish to invite local mineral and rock collectors or members of a collecting club to talk to students. Your state geologist or state natural resources agency may provide a list of minerals found in the state and possible collecting sites. Local museums or nature centers may have collections you can visit. Students who are Scouts may have collections they made to earn a badge.



Pyrite crystal with broken top. The mineral's color is pale brassy-yellow but its streak is dark gray. Pyrite (iron sulfide, FeS_2) has a metallic luster, no cleavage, uneven fracture, and often shows striations, which are the thin parallel lines on some crystal faces.



Identifying Minerals

Safety Note

Wear safety goggles when breaking mineral specimens and when working with solutions, such as acids or bases. If you get any solution on your skin, quickly wash it off with a large amount of water. Immediately tell your teacher if you spill a solution. Be careful of fumes from acids and bases. Never eat or drink in a laboratory.

In this activity, you will practice identifying minerals using your senses and available tools to determine properties of individual mineral specimens. Most people learn to identify minerals by their properties because few have access to expensive laboratory equipment.

You can determine a mineral's general color and luster without tools. Luster is the way a surface reflects light. Some adjectives that describe luster are metallic, greasy, waxy, earthy, glassy, and glossy.

Materials

Your teacher will supply these items so you can test minerals for hardness, cleavage, and streak.

- Mineral specimens
- Magnifying glass
- Streak plate (or unglazed tile, available from hardware or plumbing-supply stores)
- Items for testing hardness: copper penny, glass square (available from science-materials supply company), steel file, and steel nail. Commercial kits for testing hardness may also be used.
- Small hammer for making cleavage fragments

1	Talc
2	Gypsum
2.5	Fingernail
3	Calcite
3.5	Copper penny
4	Fluorite
5	Apatite
5.5	Window glass
5.5-6	Steel knife blade
6	Orthoclase feldspar
6.5	Hardened steel file
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Mohs' Scale of Hardness

A measure of resistance to scratching. A mineral, or object, with a higher number will scratch one with a lower number.

Procedure

1. Make a chart to record information about the properties of your mineral specimens. Fill out your chart as you work.
2. Separate your specimens by luster.
3. Separate the nonmetallic minerals by light or dark color.
4. Determine hardness of all specimens.
5. Use a mineral-identification chart from a field guide to rocks and minerals or a geology textbook or laboratory manual to try to identify your specimens.
6. To obtain more information about your specimens, determine cleavage and streak. To do a streak test, carefully rub the mineral specimen on a streak plate, which is made of unglazed tile.
7. If you need still more information, continue determining other mineral properties like magnetism and reaction to acid.
8. Complete your chart. Add information on other mineral properties if you wish.

Identifying Rocks

In the next activities, students learn to recognize the three major groups of rock—igneous, sedimentary, and metamorphic, a division based on origin. Students practice describing rock specimens, and where they can, they identify minerals in the specimens. They then try to identify each of a set of rock specimens by name as well as group.

You will need a set of rock specimens for students to work with. Detailed identification procedures and descriptions of rocks are in rock and mineral field guides and in Earth science and geology books.

Trying to identify rocks can make students anxious because many think that each specimen must be exactly named, just as minerals are. But rock classification beyond the more common types is difficult and often subjective. You may wish to remind students before they begin that they will be learning about the process of identification, and will not spend enough time studying rock (or mineral) properties to become expert.

Suggested Resources

• Brown, Vernon Max, and Harrell, James Anthony. (1991, November). Megascopic Classification of Rocks. *Journal of Geological Education, 39* (5), 379-387.

• Westerback, Mary Elizabeth and Azer, Nazmy. (1991, September). Realistic Expectations for Rock Identification. *Journal of Geological Education, 39* (4), 325-330.

Preliminary Activity: Observing and Describing

Have students practice describing rocks before they try identifying rocks. Emphasize that careful observation and clear, complete description are important for successful identification.

Give groups of four or five students a large sheet of paper and one rock specimen. Ask them to draw a picture of their specimen at the top of the sheet and to list below the picture all the words describing their specimen that they can think of. The members of a groups must agree on this list. When students have finished their lists, have each group present its specimen and list to the class. They can

try identifying any minerals they see in the specimen.

Hand out and discuss the Information Sheets "Rocks and Resources" and "The Three Groups of Rocks." Ask students if they can identify their specimen as igneous, sedimentary, or metamorphic. Have them think of potential identification problems, such as different rocks that look alike, fine-grained rocks, or sedimentary rocks with a cement different from the sediment. Ask students if they have seen human-made "rocks" at the window scene, school, home, or other places. They may mention bricks, cement, concrete, terrazzo, or plastic made to look like rock.

Safety note

Students must wear safety goggles if they will be crushing rocks to make fragments.

Activity: Identifying Rocks

Distribute the Activity Sheets "Identifying Rocks" and give students sets of rocks to work on. You may wish to use the cooperative learning strategy suggested for identifying minerals.

Have students make a chart (or computer database) to record their observations. They will describe each specimen's color and texture, and its composition, if possible. They can measure the thickness of layers in rocks and the average diameter of crystals or sediments with a ruler. Remind them to make all measurements in the metric system.

Extension: Rock Reference Cards

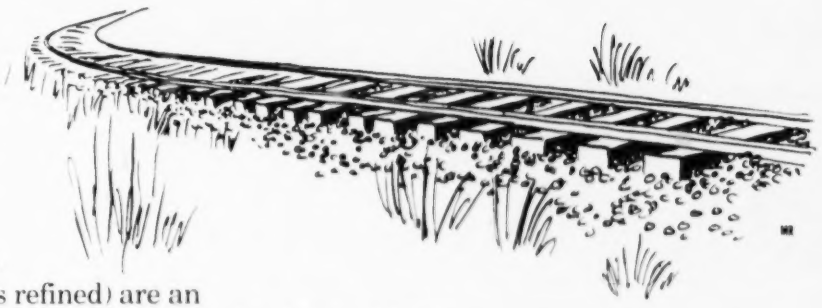
Students may make a rock-identification reference set for the school science department or media center by gluing small rock fragments to index cards. Put one fragment on a card. Record the rock name and location where found (if known), and describe its texture and composition. If rock information is in a database, the information can be printed on labels that can be stuck on the card bearing the rock fragment.

Extension: Language Connection

Students may enjoy researching the origin of mineral, rock, and soil names.

Rocks and Resources

A **rock** is a natural solid. Most rocks are made of several minerals or of pieces of other rocks. A rock may be made of only one mineral; beds of halite (called rock salt, from which table salt is refined) are an example. Some rocks are made of **volcanic glass**, which is lava (made of several chemical compounds) that cooled so fast the minerals could not crystallize. Some rocks, like coal or coral, are made of organic substances.



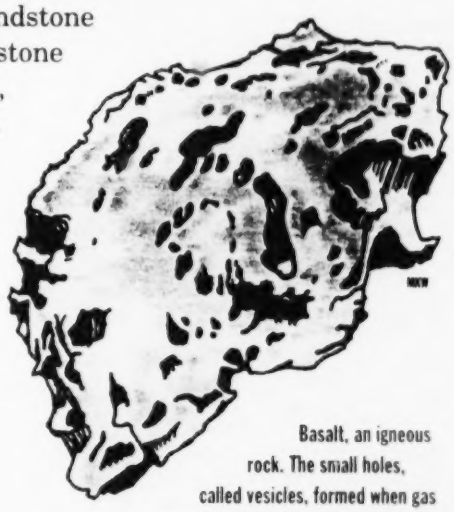
One use of crushed stone is under railroad tracks. Basalt, limestone, and granite are commonly used.

Knowledge of rocks helps people find mineral resources. Oil often lies in the spaces between sand grains in a sandstone. Some copper ores are associated with rocks formed deep beneath volcanoes. Gypsum and other dissolved salts, like halite, precipitate in layers when seawater evaporates and are in sedimentary rocks deposited in very shallow seas. Lead ores are found in veins in limestone, disseminated in shale or in volcanic rock, and in certain metamorphic rocks. Some rocks, like sandstone (the source for glass), limestone (used as building stone and crushed stone, in agriculture, and for cement), granite (building stone, crushed stone), and basalt (crushed stone) are resources themselves.

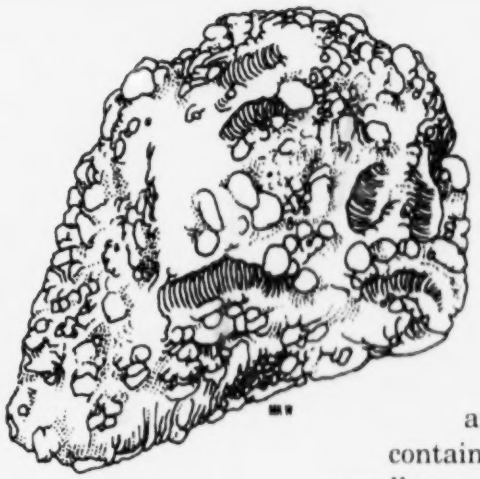
Groups of Rocks

Rocks are organized in three major groups—igneous, sedimentary, and metamorphic. The classification is based on origin.

Igneous rock forms from a molten state. Molten rock beneath Earth's surface is called **magma**. When magma flows onto Earth's surface, from volcanoes on land or sea floor, it is called **lava**. Cooled lava is called **extrusive** igneous rock; **basalt** is an example. When



Basalt, an igneous rock. The small holes, called vesicles, formed when gas escaped from the cooling lava. Basalt is a major source of crushed stone.



Conglomerate, a sedimentary rock. Pebbles cemented together in a conglomerate can be made of minerals or of other rocks. These pebbles are made of quartz.

magma cools and solidifies while it is still under Earth's surface, the rock is called **intrusive**. **Granite** is an example.

Sedimentary rock forms by accumulation and compression or cementation of pieces of other rocks, minerals, shells, bone fragments, or plant materials. The pieces are called **sediment**. **Sandstone** forms from sand, **shale** forms from clay, **conglomerate** forms from gravel. Sediment is moved by water, wind, ice, and animals and plants. Some sedimentary rocks contain fossils. The material cementing the sediment is usually quartz or calcite, but other minerals, like hematite, may also act as cementing materials.

Metamorphic rock forms from other rocks when they are transformed by temperature, pressure, or gain or loss of chemical components. These changes usually occur deep in Earth's crust, where temperature is very high, pressure is very great, and chemically active fluids percolate through the rocks. **Gneiss**, **schist**, **slate**, and **marble** are the common metamorphic rocks.

Identification of Rocks

Color, texture, and composition serve to identify most rock specimens as igneous, sedimentary, or metamorphic. Rock properties are different from mineral properties. Tests for minerals, while they help determine a rock specimen's composition, identify only minerals, not rocks.

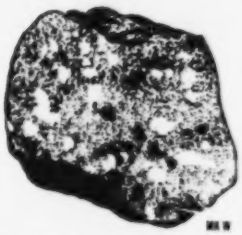
Slate, a metamorphic rock, has microscopic grains and thin, platy foliation.

Color means the rock's general tone, dark or light. The rock's actual color–red, green, banded dark and light, or even gray with pink crystals–is also useful.

Texture is the way the rock looks and feels—the size and shape of the pieces it is made of, and the way the pieces and spaces between them are arranged. A rock may be fine-grained (made of pieces not easily seen with the unaided eye, that is, pieces less than about one millimeter in diameter) or coarse-grained. The pieces may

be angular or rounded or in between and of uniform or mixed size. Large pieces may be embedded in fine-grained material, or pieces may be layered by size. Interlocking crystals may be of the same or different sizes.

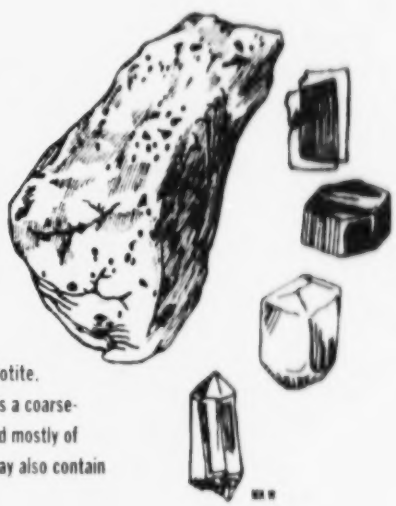
If a rock is made mostly of crystals, the texture is called **crystalline**. Intrusive igneous rocks like granite cool slowly and become coarse-grained crystalline rocks. Extrusive igneous rocks cool rapidly and are usually fine-grained. Some cool so fast they are glass because crystals did not have time to form. Crystals usually have sharp edges or straight sides or boundaries.



This igneous rock has light colored orthoclase feldspar crystals in a darker, fine-grained matrix. The rock is called a porphyry, and the texture is porphyritic. Many kinds of igneous rocks can be porphyritic.

Sedimentary rocks made of pieces of other rocks or minerals have a fragmental texture. **Pyroclastic** rocks are sedimentary rocks made of debris ejected by volcanoes. (Pyro means fire, clastic means "broken.") The rock fragments are igneous going up in the air and sediment coming down, as the pieces fall to the ground and are cemented together.

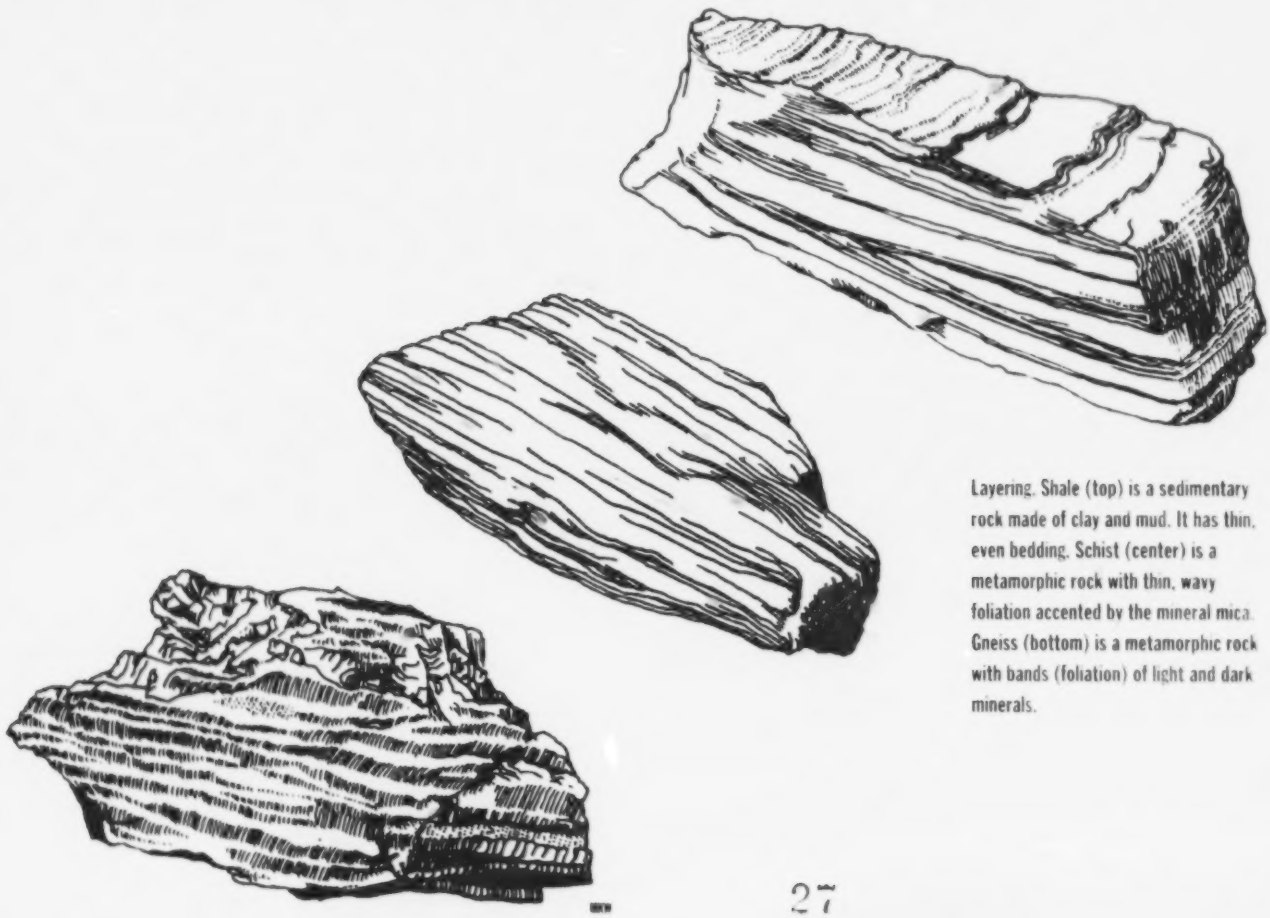
The texture of a rock may be uniform or the pieces may be arranged in clumps, in layers, in layers of layers, and in many other ways.



Granite specimen with associated minerals Biotite, Hornblende, Orthoclase, and Quartz. Granite is a coarse-grained crystalline igneous rock. It is composed mostly of crystals of feldspar minerals and quartz and may also contain biotite mica and hornblende.

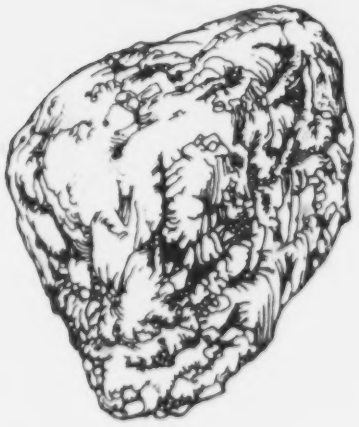
Layered texture is an good identification aid. Igneous rocks are usually crystalline and are seldom layered. If a specimen has layers that appear flat or curved and if pieces are visible, then the rock is usually sedimentary and the layers are called **bedding**. Bedding can range from very thin to massive. (Massive beds can be as thick as several feet and would not be apparent in a small specimen.) Most metamorphic rocks are crystalline and have some degree of layering, called **foliation**, which is the parallel arrangement of crystals. Foliation is often bent, twisted, or otherwise distorted.

Composition describes the minerals found in a rock. Many igneous and metamorphic rocks are defined by characteristic groups of minerals.



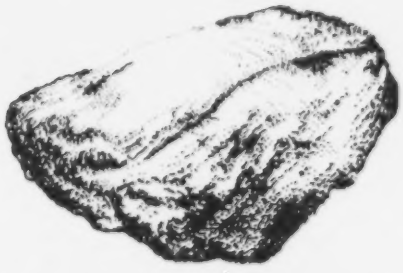
Layering. Shale (top) is a sedimentary rock made of clay and mud. It has thin, even bedding. Schist (center) is a metamorphic rock with thin, wavy foliation accented by the mineral mica. Gneiss (bottom) is a metamorphic rock with bands (foliation) of light and dark minerals.

The Three Groups of Rocks



Granite

Intrusive Igneous rock.



Sandstone

Classic sedimentary rock.

Folded Gneiss

Metamorphic rock.

Igneous Rock

- Classified by texture, composition.
- Usually composed of intergrown mineral crystals, which may vary in size.
- Usually made of two or more minerals.
- May be light- or dark-colored (color depends on composition, except for glassy rocks).
- May be fine-grained or glassy (extrusive), sometimes with vesicles (openings) or glass fibers.
- Usually has no layering.
- Rarely reacts with acid.
- Normally contains no fossils.

Sedimentary Rock

- Classified by texture, composition.
- Usually composed of pieces cemented or pressed together.
- May have uniform or variable particle size.
- Usually has pores between pieces.
- Often contain fossils.
- May contain crystals (evaporites, some limestones).
- Often has bedding, usually flat or curved.
- May have features like cross bedding, mud cracks, raindrop impressions, worm burrows.
- Has great color variety.
- May react with acid.

Metamorphic Rock

- Classified by texture, composition.
- Usually composed of intergrown mineral crystals, which may vary in size.
- May have layers of visible crystals (foliation) or may be dark and fine-grained.
- May have bent or curved foliation.
- May have alternate bands of light and dark minerals.
- May be composed of only one mineral (marble, quartzite).
- May react with acid (marble).
- May have no crystals or foliation (anthracite coal).
- Rarely has fossils.
- Rarely has pores or openings.

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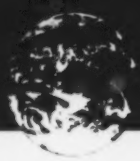
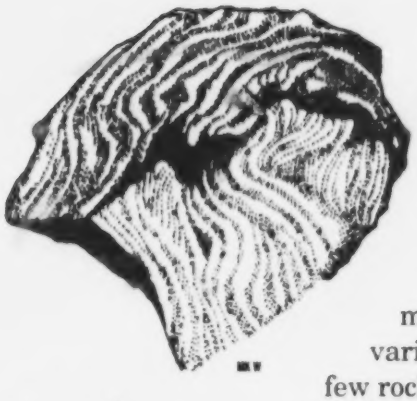


Identifying Rocks

Mineral resources are found in rocks, and many rocks, themselves, are important natural resources. In this activity, you will practice identifying rocks using your senses and available tools.



A piece of smooth, unfossiliferous, medium-bedded, red shale.

Your senses will help you recognize the three major groups of rock—igneous, sedimentary, and metamorphic. The grouping is based on origin. Each group contains many kinds of rocks distinguished by texture and composition.

Minerals are easily identified using appropriate tests because they have definite chemical compositions and crystal structures. Rocks can be harder to identify because they are mixtures, and a mixture can have many variations. Almost any rock variation can be found somewhere on Earth, but only a few rocks are common. The common igneous, sedimentary, and metamorphic rocks can usually be identified by appearance. You will practice identifying some common rocks with the classification scheme that geologists use.

Similar kinds of rock are grouped under a single name. For example, shale is a sedimentary rock made of clay. You may find red, green, gray, or black shale; shale with or without fossils; thin-bedded or massive shale; smooth or rough shale. You may find a smooth, unfossiliferous, medium-bedded, red shale. These adjectives describe rock properties that you can identify using your senses. The order of the adjectives puts the most important or obvious property—like "red"—next to the noun that names the rock: red shale.

How a rock is made determines how it looks. Use the Information Sheets "Identifying Rocks" and your new ability to identify minerals to help to begin sorting rock specimens into igneous, sedimentary, and metamorphic groups.

Make a chart to record your observations. You will be describing color and texture, and also composition, if possible. The thickness of layers in specimens and the average diameter of crystals or sediment pieces can be

measured with a ruler. You may need to use a magnifier or microscope. Remember to make all your measurements in the metric system.

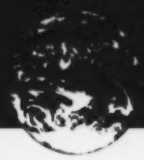
Problem Rocks

Sometimes identifying a rock specimen is easy; sometimes it is difficult or impossible. Different kinds of rock can look alike, especially if they are dark and fine grained. People use magnifiers—from a hand-held magnifying glass to the most advanced microscope—to help determine the physical characteristics of problem rock specimens and the minerals in them. Chemical and physical tests help determine composition; some tests require expensive laboratory equipment.

When a rock specimen's properties are obvious, it is usually easy to identify the specimen as igneous, sedimentary, or metamorphic. Some specimens are impossible to identify without laboratory work.

Questions

1. What rock property do you find most helpful in identifying specimens? Which helped the least? Why?
2. What mineral tests helped you determine the composition of your rock specimens?
2. What other tests would you like to do to help identify specimens?
3. Where could you get help identifying rocks and minerals?



How Do Rocks Form?

Students are now familiar with the appearance of common types of igneous, sedimentary, and metamorphic rocks. The next activity reinforces their new knowledge by letting them generate "rocks" using crayon shavings. It is adapted from "Color Me Metamorphic," by Donald L. Birdd, *The Science Teacher, 57* (4), April 1990, pp. 20-25. (The activity also appears in *Earth Science Investigations*., 1990, Margaret Oosterman and Mark Schmidt, Eds. Alexandria, VA: American Geological Institute.)

Activity: Making "Rocks"

This activity takes at least two class periods. Students first shave crayons with pocket pencil sharpeners, simulating sediment created by weathering and erosion. They "deposit" the "sediment" by putting the shavings on aluminum foil in layers of different colors. They fold the foil over the layers and use a workbench vise to apply mild pressure to the packet, creating "sedimentary rock."

Safety Note

Cover all desks with newspaper and keep extra newspaper handy. Students must wear lab aprons and safety goggles at all times during this activity. When they melt crayon wax over the hot plate, they must be especially safety conscious. They must not drop wax on the hot plate and or heat the wax to the spattering point.

The next step is metamorphism. After students examine their "sedimentary rock," they rewrap the packet and again press it in the vise, this time with as much force as they can apply.

After students examine the "metamorphic rock," they heat pieces of it with any leftover "sediment" in an aluminum pie pan on a hot plate to make "magma." To simulate extrusive and intrusive igneous rocks, students pour some "lava" directly onto ice, some into cold water, and some into hot water. Some is left to cool at room temperature. When students study the cooled "igneous rocks" in the next class period, they will see the differences in grain size (texture) caused by different cooling rates.

Hand out the Activity Sheets for "How Do Rocks Form?" You may wish to discuss plate tectonics and the origin of rocks before you start. (See discussions and diagrams in the Planet unit.)

Separate the class into four groups. Go over safety procedures. Have students prepare to record and illustrate their observations at each rock-making step.

Give each group one of the crayon colors, four crayons per student. You may need to demonstrate the crayon-shaving technique. While the students process the crayons, lead a class review of what they know about weathering, erosion, and deposition.

When the shavings are ready, give each group a square of aluminum foil, to be folded in half. Each group, in turn, will put its shavings on each piece of foil in a layer one centimeter thick and eight centimeters square, creating a stack of colored layers; they have deposited the "sediment."

As the groups press their "sediment" packets in the vises to make "sedimentary rock," then press more to make "metamorphic rock," discuss other processes that work to make rock, such as cementation and crystallization.

Before students begin melting wax to make "igneous rock," assign a cooling process to each group. The "igneous" part of the activity requires careful supervision due to the danger of burns from hot wax and the hot plate.

When students observe the textures of the four cooled wax masses, you may wish to discuss volcanic eruptions in different settings, such as under ice as in Iceland or under water as at Loihi, the newest Hawaiian volcano.

Safety Note

When students are ready to melt the crayon "rocks" on the hot plates, review safety procedures.

Selected Answers to Questions in "How Do Rocks Form":

1. Similar: Physical forces break rocks into small pieces. Different: Chemical weathering also occurs. Pieces are transported by water, wind, ice, plants, and animals.
2. Cementation, crystallization.
3. High temperature, chemically active fluids.
4. The slower the cooling, the coarser the texture.

How Do Rocks Form?

In this activity, you will make "rocks" from pieces of crayons. You will create "sediment," deposit it, press it into "sedimentary rocks," press it more to change it to "metamorphic rock," and melt pieces of "sediment" and "rock" into "igneous rock." The list of materials and the procedure follow the diagram below, which shows the steps of your rock-making process.

Safety Note

You must wear lab aprons and safety goggles at all times during this activity. When melting crayon wax on the hot plate, you must be especially safety conscious. Do not drop wax on the hot plate or heat the wax to the spattering point.

Materials

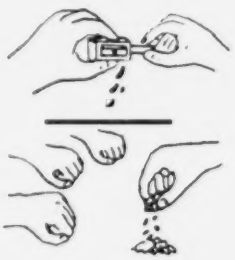
- Safety goggles
- Laboratory aprons
- Crushed ice
- Cold water
- Wax paper
- Hot water
- Workbench vises (brought from home or used in school shop)
- Pieces of board, two for each vise, 20 cm (about 8 in) long, 12.5 cm (about 5 in) wide, and 2.5 cm (about 1 in) thick
- Hot plates with flat surfaces, one for each student group
- Tongs, two pairs for each group
- Pocket pencil sharpener, one per student
- Small flat dishes (like petri dishes) for storing pieces of "rock" for study
- Wax crayons in four distinctly different colors such as red, yellow, blue, and green; four of one color per student
- Aluminum foil, 45 cm by 45 cm (18 in square), two squares per group
- Aluminum foil disposable pie pan, 10 cm (about 4 in) in diameter or rectangular pan of similar size, two per group
- Aluminum foil to line pans
- Paper bags or envelopes, one per student
- Newspaper, enough to cover all surfaces

Procedure

1. Cover your desks or tables with newspaper to protect the surface.
2. Put down a square of wax paper to catch crayon shavings.

Making Sediment

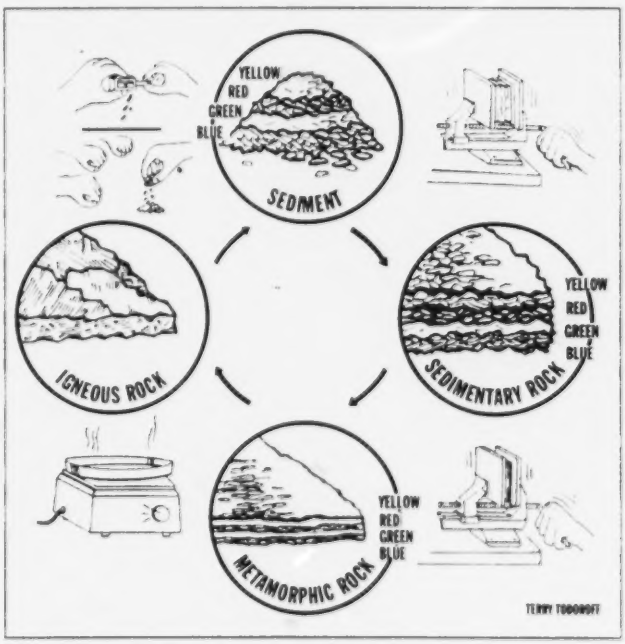
3. Strip the paper wrapper from the crayons your teacher hands out. Hold a crayon over the wax paper and carefully turn it in the pocket pencil sharpener until you have converted it into shavings. Process all your crayons in the same way.

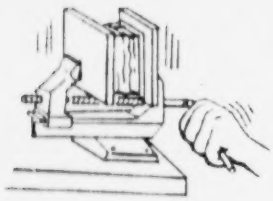


4. When you have finished shaving all your crayons, carefully wrap the wax paper around the shavings pile and store the pile in a paper bag or envelope.
5. Put the square of aluminum foil that your teacher gives you on your desk. (Your desk should be covered with newspaper.) Fold it in half.

Depositing Sediment

6. From your group's crayon shavings, put enough on your piece of foil to make a layer 1-cm thick and 8 cm-square. Go to the other groups and place a similar shavings layer on their foil pieces. Each group proceeds



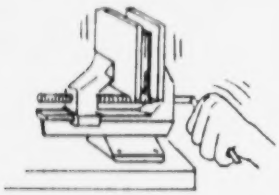


in turn so that the four layers of colored shavings on each foil piece are in the same order. You have deposited your "sediment." Begin your observations of the rock-making process by sketching the stack of layers. Label your picture.

7. Carefully fold the foil over the layers, leaving a 1 cm margin on each side of the stack.

Making Sedimentary Rock

8. Place your group's foil-wrapped shavings packet between the boards, like a sandwich, and put the "sandwich" in the vise. Apply light to medium pressure.



9. Release the pressure and remove your "sandwich," carefully open the foil, and observe the contents. Remove the compressed part of the shavings stack, break it in two parts, and examine the broken edges and the layers. This is your "sedimentary rock." Describe the way the layers look. How do they compare to the original layers? What happened to the spaces between the shavings? Record and illustrate your observations.

Making Metamorphic Rock

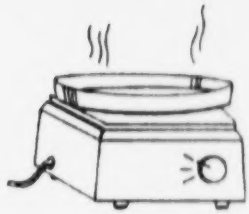
10. Transfer any loose shavings from the foil and one piece of the compressed shavings ("sedimentary rock") to a small dish. Return the other piece of compressed shavings to the foil and fold the foil over it as before.

11. Place the foil-wrapped packet between the boards, put the "sandwich" in the vise, and apply as much pressure as you can.

12. Release the pressure and remove your "sandwich," carefully open the foil, and observe the contents. Break open the compressed shavings and observe the texture. What happened to the layer thickness, the fragment shape, and the surface that was against the foil? Record and illustrate your observations.

13. Save a piece of the "metamorphic rock" in the dish with the shavings and the "sedimentary rock."

Making Igneous Rock



14. Your group will melt "sediments" and "sedimentary and metamorphic rocks" in an aluminum pan on a hot plate to make "magma." Cover the hot plate with aluminum foil. In the pan put all the crayon "rock" and "sediment" fragments except those in the small dish, which you have kept for comparison.

15. Put the pan on the hot plate and turn the temperature control to medium. Observe all safety precautions.

16. Line a second aluminum pan with a piece of foil and set it aside.

17. When most of the "rock" has melted, turn the hot plate off. DO NOT LET THE WAX HEAT TO THE SPATTERING POINT. The heat energy in the molten wax will melt the remaining solid pieces.

18. While the wax is still molten, make an "igneous rock" in the empty, foil-lined pan by one of these processes. Your teacher will tell you which to use. Observe what happens to the molten wax. Record and illustrate your observations. Do not disturb the cooling wax.

A. Fill the empty pan with crushed ice. Pour the molten wax on the ice.

B. Fill the empty pan with cold water. Pour the molten wax into the water.

C. Fill the empty pan with hot water. Pour the molten wax into the water.

D. Put the molten wax into the empty pan. Let the wax cool at room temperature, in a place where it will not be disturbed.

19. Let the wax cool in the pan until the next class period. Examine the outside of the cooled "Igneous rock." Break it open and look at its texture. Record and illustrate your observations.

Questions

1. How are real weathering and erosion similar to making crayon shavings? How are they different?
2. What processes produce sedimentary rocks besides pressure?
3. You made "metamorphic rock" by applying pressure. What other factors help metamorphose rocks?
4. Compare the textures of "igneous rock" formed in the four cooling processes. What relation do you see between rate of cooling and texture?

Return to the Project: Rocks, Landscape, and Soil

From their practice in identifying minerals and rocks, students should be able to decide which materials and objects in their window scene and which samples they collected from the scene are minerals or rocks. After students enter their mineral and rock information on the big chart of objects in the window scene, they will try to find out where these mineral resources came from.

Activity: Rocks in the Window Scene

Many buildings are built of stone or have stone slabs as facing.

Distribute the Activity Sheets for "Rocks in the Window Scene." Have students decide whether any minerals or rocks are in the window scene. If you had the students form groups for the field trip, you may wish to ask each group to discuss its part of the scene.

Ask students whether the minerals or rocks are in a raw (natural) or processed form. For example, a big boulder is in its natural form; crushed rock on a rail bed has been processed, as have copper in electrical wire and gemstones in jewelry.

Students should fill in the column "Resource Composition" on the "Window Scene" chart for any window scene objects that are minerals or rocks or that are made from minerals or rocks.

If you are in a built-up area, you may wish students to find out what rocks (or perhaps sediments) underlie the buildings. They may find rocks as facing or decoration on buildings or placed in parks or yards. They may find various building stones to study (for example, granite, gneiss, marble, limestone, or sandstone).

Activity: Where Do Mineral Resources Come From?

Ask students to find out where the mineral resources on the big chart come from. For example, Georgia and South Carolina are major producers of kaolin clay, which is used mainly in making coated (shiny) paper—the kind that catalogs are printed on. Kaolin is also used in pottery and dinnerware. Clay for making bricks is more common and may have a local source. Have students record the information under "Resource Location."

Kaolin mining in the U.S. is concentrated in Georgia and South Carolina, the narrow shaded area on this map. Kaolin is also mined in North Carolina, Vermont, New Mexico, Arizona, Utah, Nevada, Idaho, Montana, and at a few sites in other states. Kaolin is a weathering product of igneous rocks and metamorphic rocks that were formed from igneous rocks.

Suggested Resource

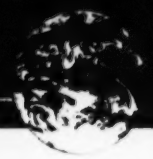
United States Mineral Resources, U.S. Geological Survey Professional Paper 820. (1973). Washington, DC. U.S. Government Printing Office.

Extension: Community Connection

Ask students to find out what businesses in the community, county, or state process minerals or rocks. Obtain brochures about the companies and samples of their raw and processed materials for a bulletin board or hall display. Invite a company representative to talk to the class, or take a field trip to a company's facility.

Extension: Geography Connection

Have students find out what mineral resources their state is famous for. Mark resource locations on a state map. Research where else on Earth they might find those resources.



Rocks in the Window Scene

Examine your drawing of the window scene and the objects you collected at the site. Use your new knowledge to identify any minerals and rocks in the scene, or to identify specimens from another site.

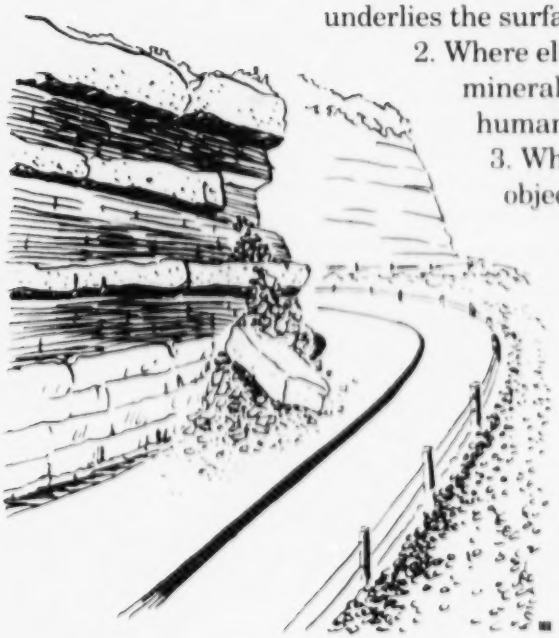
Adding to the Big Chart

On the big chart of objects from your window scene, fill in the column "Resource Composition" for any minerals or rocks. Do the same for objects made from minerals or rocks.

Now you will start a new column, "Resource Location." Try to find out where the mineral resources used in objects in the window scene came from. Write this information in the new column.

Where Do Mineral Resources Come From?

1. Where at the site of your window scene did you find minerals or rocks? Are the rocks **bedrock** (the rock that underlies the surface), sediment, or placed by humans?
2. Where else in your community might you find minerals or rocks? Are these places natural or human-made settings?
3. Where might the mineral resources in the objects from the window scene have come from? Are any resources local? Examples might be clay for bricks, limestone for cement, or sand and gravel for construction.



Sketch of a highway cut into a cliff. The sedimentary rock layers are bedrock. The pieces that have fallen to the road are sediment. The fill to the right of the highway is rock placed there by humans.

How Are Natural Resources Formed?

To help them find natural resources, people have learned to identify minerals and rocks. New geological ideas have led to new ways of locating many natural resources, especially the ores of metals. **Ore** is any mass of rock that has enough useful minerals concentrated in it to make mining profitable.

Understanding the effects of plate tectonics, like earthquakes and volcanoes helps people understand how ores formed. Understanding weathering and erosion processes helps people understand how minerals are concentrated in one place. Understanding our environment helps people know where to look for mineral resources.

Suggested Resource

• Brimhall, George. (1991, May). The Genesis of Ores. *Scientific American, 264* (5), 84-91.

Extension: Life at Hydrothermal Vents

In 1977, scientists discovered large groups of clams, mussels, tube worms, crabs, and other animals at deep-sea hydrothermal vents. The primary producers in this unique food web are chemosynthetic bacteria.

The vents are at midocean ridges, places where lava from undersea volcanoes forms new crust as Earth's plates move apart. The vents occur where seawater, superheated from contact with magma, emerges from the ocean floor. Metallic minerals dissolved in the hot water precipitate on contact with the cold seawater and form large mounds. (Many ore bodies mined today formed as vent mounds millions of years ago.)

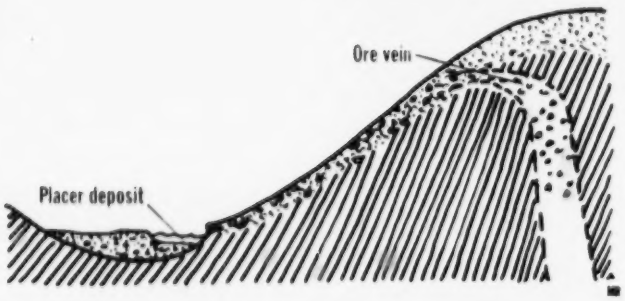
Have students report on the vents and their minerals and on the vent animals and their food web.

Suggested Resources

• Childress, James J., Felbeck, Horst, and Somero, George N. (1987, May). Symbiosis in the Deep Sea. *Scientific American, 256* (5), 114-120. Food web and carbon cycle at vents.

• Corliss, John B., and Ballard, Robert D. (1977, October). Oases of Life in the Cold Abyss. *National Geographic, 152* (4), 441-453. First descriptions of vent life, from the Pacific Ocean.
• Lutz, Richard A., and Kennish, Michael J. (1993, August). Ecology of Deep-Sea Hydrothermal Vent Communities: a Review. *Reviews of Geophysics, 31* (3), 211-242. Color photos, complete description of food web.
• Rona, Peter A. (1992, October). Deep-sea Geysers of the Atlantic. *National Geographic, 182* (4), 105-109. Vents and animals in the Atlantic Ocean.

Landscape Information



Pieces of an ore mineral, like gold, from a weathered ore vein move downhill under gravity, fall into a stream where water moves them, and then they accumulate as a placer in the stream sediment.

People have learned to "read" Earth's surface as a guide to resources—to look for gold or diamonds in certain river gravels, for example. People know that low hills along the coast of the Gulf of Mexico may be salt domes that have oil on their flanks. Plants that need specific metals for their nutrition can help identify an area with potential resources. (Students may enjoy learning about the relatively new science of geobotany.)

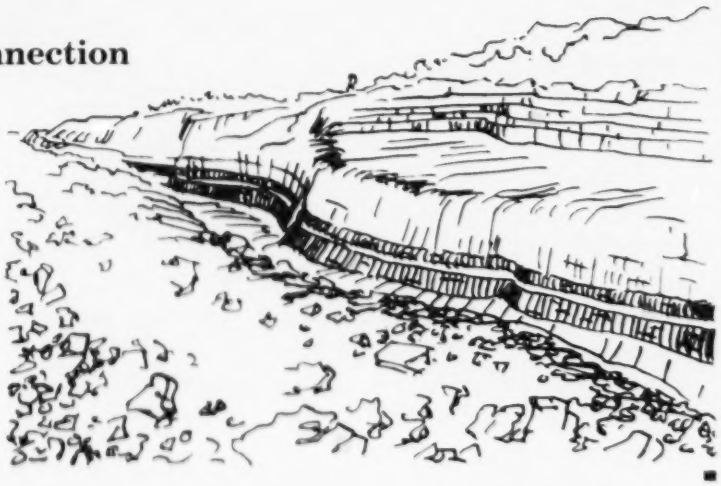
Because igneous, sedimentary, and metamorphic rocks form under different conditions, they have different properties, as students saw when they made "rocks." Different rocks react differently to surface processes and look different in the landscape. (You will find descriptions of surface processes and rock reactions in Earth science, geology, geomorphology, and physical geography books.) People have learned to identify rocks that may be hidden under soil. They study the "look" of the landscape—the height of hills, the angle of slopes, the kinds of plants present.

The landscape also reveals human efforts to extract natural resources. For example, features found at many places in the Appalachian Plateau are the winding horizontal cuts on mountainsides and piles of rock rubble from strip mining coal. Similar rubble piles lie near

phosphate mines in Florida and Montana, kaolin clay diggings in the southeastern United States, and other open-pit operations such as copper mines in the western United States.

Extension: History Connection

Gold! A discovery sparks migration—a gold rush. Students may research and report on the history of gold, its uses, or famous gold rushes, in South Dakota, California, or Alaska, for example. They should include environmental effects of digging for gold.



Old strip mines still scar the Appalachian landscape.

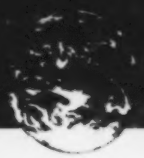
Activity: Your Landscape

Have students describe the overall landscape setting of the window scene, using the list of everything in the scene that they made in the first activity. Include human activity that may have altered the landscape.

Combine the students' grid maps with a local or regional map to show the location of the scene and features like hills, valleys, and streams in the landscape that surrounds the scene. If students found local natural resources for objects from the window scene, mark their locations on the map.

Ask students if they can match landscape elements to different kinds of rock. In humid areas, where water dissolves limestone, that rock usually underlies valleys, but in dry areas, it often forms ridges. Sandstones are usually ridge makers everywhere, and shales underlie valleys. Igneous rocks usually form hills. Metamorphic rocks have different landscape expressions, because they have many different mineral compositions.

Depending on the landscape in your area, you may wish to have students work in groups on this activity. Have the students keep this new information together with the chart and other materials from the window scene.



How Did Your Landscape Form?

Earthquakes, volcanoes, and mountains result from the motion of Earth's plates. Students learned in the Planet unit that earthquakes and volcanoes mark many plate boundaries. Mountains form near the boundaries, as plates collide.

If the plates are in constant motion, why isn't Earth completely mountainous? What makes valleys, rivers, plains, and other landscape features? **Weathering** breaks down rock exposed at Earth's surface to sediment and **erosion** moves sediment. When sediment comes to rest, even temporarily, **deposition** has occurred. **Soil** is the residue of weathering.

How a landscape looks depends on climate, vegetation, rock, and humans. How much rain falls? What are the summer and winter temperatures? What is the wind direction? How hard does it blow? What kind of rocks underlie the surface? What sort of material is on the surface? How has human activity changed the surface?

Have students add to their landscape description the answers to these questions. Some sources of information are local Earth science teachers, the U.S. Department of Agriculture's Natural Resources Service, the State Geologist, and weather services at local airports and television stations.

Extension: Topographic Maps

Obtain the U.S. Geological Survey topographic maps for your area and compare them to the map the class has developed. If possible, examine a large-scale map (such as 1:24,000), which shows a small area in great detail, and a small-scale map (1:100,000 or 1:250,000), which shows a larger area in less detail. Maps can be purchased from USGS (Map Sales, Box 25286, Denver, CO 80225) or at sporting goods or camping supply stores. You may be able to look at the maps in your local library.

What Is Weathering?

Weathering is the physical and chemical alteration of rocks at Earth's surface. Frost and plant roots pry rocks

apart. Heat and cold loosen mineral crystals that water in the atmosphere and ground is slowly dissolving. (See "Acid Rain" diagram in the Air unit.) Chemicals from the action of decomposers and other organisms in soil help rock decompose. (See the "Carbon Cycle" diagram in the Life unit.)

As the parent rock, or bedrock, and its minerals break down, new minerals form. Water carries away soluble chemicals and leaves behind insoluble ones. Where weathering has gone on uninterrupted for a very long time, people have found large, residual deposits of useful mineral resources such as the brightly colored copper minerals malachite (green) and azurite (blue), kaolin and other clays, bauxite, which is the only useful ore of aluminum, and the iron ore limonite.

Erosion moves sediment from one place to another. Erosion can be very damaging to the land. This small stream in Utah (upper picture) eroded a gully about 20 feet deep (lower picture) in 35 years.

What Is Erosion?

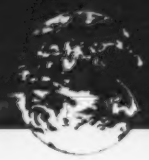
Erosion is the process of moving sediment and altering Earth's surface under the influence of gravity. Erosion takes many forms, from sudden mudflows and landslides to very slow movement called creep. Agents of erosion are gravity, liquid water, wind, ice, plants and animals, and humans.

Activities: Weathering and Erosion

Ask students to describe examples of weathering and erosion in their window scene and its surrounding landscape. Hand out the Activity Sheet "How Did Your Landscape Form?"

Safety Note

Students must wear safety goggles for the erosion experiment. To drop water from two meters, they may need to stand on chairs. Be sure they stand facing the back of the chair, to lessen the danger of accidental tipping.



Answers to "Fast Weathering"

1. The steel wool is rusting.
2. By color, texture, streak. The red substance is hematite, which forms when iron combines with oxygen (oxidation). The orange substance is limonite, which is a group of iron oxide minerals combined with water (hydration).
3. The water and air in the jar acting on the steel wool.
4. Material containing iron will rust when exposed to a humid atmosphere. In dry areas, rust forms slowly or not at all.
5. Some objects may be rusty. Some may look decayed, dirty, dried, faded, frayed, pitted, or otherwise changed.

You may do the first activity, "Fast Weathering," as a demonstration, or have the students work in groups or individually. While the steel wool reacts (a few days), do the activity "One-Drop Erosion."

Students may work in groups. Three groups can handle dry and wet measurements of one size sediment; with six groups, you can assign one set of measurements to each and finish the experiment sooner. Use plain paper like butcher paper if you have it; splash is hard to see on newspapers. You may wish to discuss why the measurements are repeated three times in the activity.

Some students may need help with their bar graphs. If computers are available, students may enter their data and use an application to draw the graph.

When the experiment is finished, ask the class to discuss erosion they see in the window scene or other appropriate location.

Activity: The Rock Cycle

Hand out the Activity Sheet "The Rock Cycle." Use it to review with students what they have learned about minerals, rocks, weathering, and erosion. (The instructions for the activity are on the Activity Sheet "How Did Your Landscape Form?")

Selected answers to "One-drop Erosion:"

1. For any sediment size, crater diameter and splash distance are greater in dry sediment.
2. The smaller the sediment size, the greater the crater diameter and splash distance.
3. Put gravel over sand or silt. The water drop produced no crater or splash in gravel. Introduce something to stop splash, like grass or other vegetation.

How Did Your Landscape Form?

In these activities, you will see weathering and erosion in action. These processes work continuously to change the landscape and to expose or concentrate mineral resources at Earth's surface.

Fast Weathering

Place a piece of uncoated steel wool in a jar. Add water to a depth of about 1 cm. Close the jar. Observe the steel wool daily for several days.

1. What changes do you see on the steel wool? What changes in the water?
2. How would you identify the substances that are forming on the steel wool? What are the minerals?
3. What do you think caused the changes?
4. How is this an example of weathering?
5. Do objects in your window scene show similar changes? Do they show other signs of weathering?

One-Drop Erosion

You have probably seen running water wash away dirt and can appreciate the power of streams and rivers to move sediment. And you know that water splashes if you pour it fast. What do you think the power of one raindrop is? Can one drop cause erosion?

You will be working in groups to measure the crater and the splash caused by one drop of water falling on different sediments. You will release drops from heights of one meter and two meters. The materials to test are dry and wet silt, dry and wet sand, and dry and wet pea gravel.

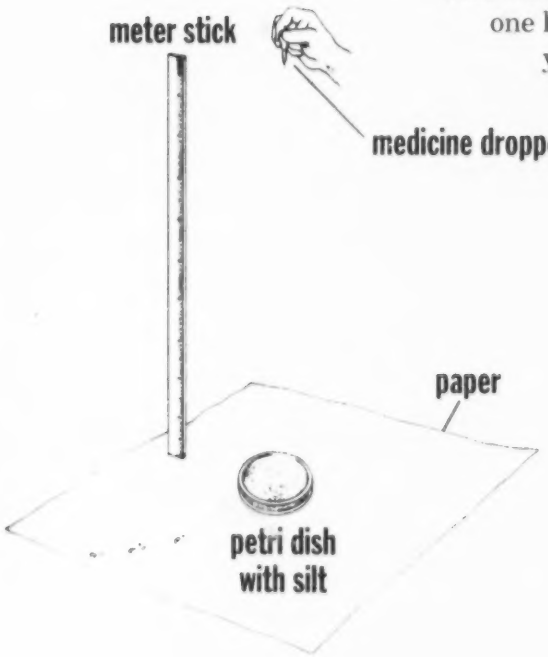
Silt grains are very fine, less than 0.1 mm in diameter. Dust in the air and mud in a puddle are silt size or smaller. (Clay particles are smaller than 0.004 mm.) Sand grains are 1 to 2 mm across. Pea gravel pebbles average 0.5 to 1 cm in diameter. Bags of sand and pea gravel are available at hardware or garden stores.

Materials

- Safety goggles
- Small dishes like petri dishes
- Pieces of paper, 60 cm square
- Water
- Medicine dropper
- Meter stick
- Supply of dry sediment: silt, sand, and pea gravel

Procedure

1. Prepare a chart to record your observations of crater diameter and distance that the splash travels for drop impacts from 1 m and 2 m height on each kind of sediment. To make sure you achieve accurate measurements, do the procedure three times for each type of sediment from each height. (You will have six crater-diameter columns and six splash-measurement columns: first drop, second drop, and third drop from 1 m height, and first, second, and third drops from 2 m.)
2. Put on safety goggles. Fill a petri dish with sediment to a depth of about 1 cm. Smooth the surface. Put the dish in the middle of one of the large pieces of paper. Fill the dropper with water, hold it 1 m above the sediment, and let one large drop fall. (You may wish to practice your drop technique.) What happens when the drop hits the sediment? Describe the impact crater. Use the meter stick to measure the splash distance, from drop impact to farthest splatter.



3. Do the experiment twice more. For each measurement, use fresh material in the dish and put the dish on a new piece of paper. If your group will measure dry and wet sediment, do the dry measurements first.
4. From the data collected by the class, construct one bar graph to show crater diameter and another to show splash distance. Average the three measurements for each height and each sediment.

4. From the data collected by the class, construct one bar graph to show crater diameter and another to show splash distance. Average the three measurements for each height and each sediment.

Questions

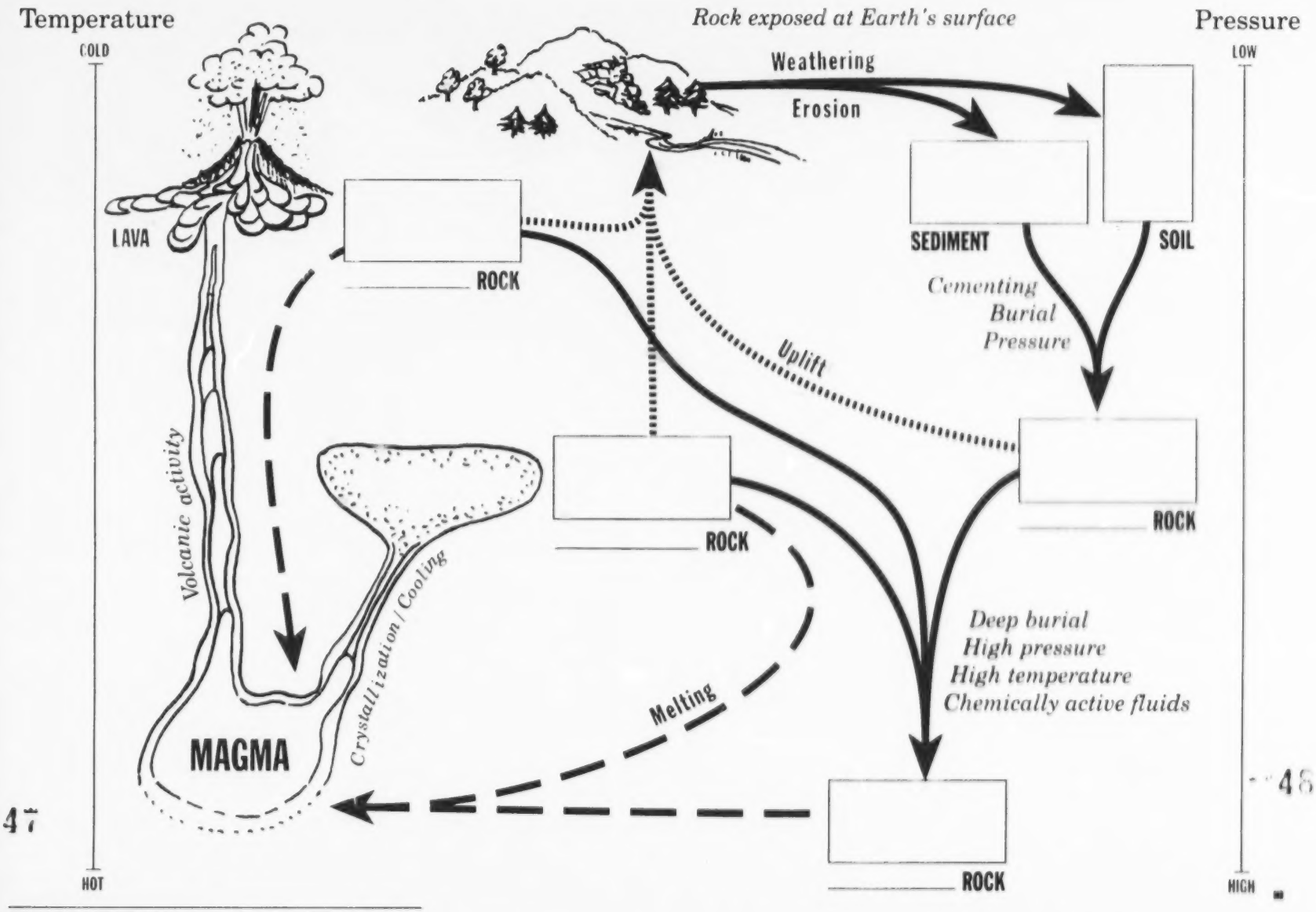
1. How do dry and wet sediments compare for crater diameter? for splash distance?
2. Does sediment size make a difference in crater diameter? in splash distance?
3. If you wanted to reduce erosion in sediment, that is, reduce or stop splash, what might you do? Use evidence from your experiment to support your suggestions.
4. What observations might you make outdoors, to confirm your experimental results?
5. Is erosion active in your window scene or another place you are familiar with? Describe the erosion and suggest tactics to control or stop it.

The Rock Cycle

Earth's tectonic activity, weathering, and erosion work together to move the rock of whole continents, break up rocks, and move sediment to form more rock. Any kind of rock can be **metamorphosed** if it is buried or moved by one of the plates deep beneath Earth's surface. Buried rock can melt to become igneous rock. All rock at Earth's surface is ultimately broken into sediment by weathering and carried away and deposited by erosion. Sediment turns to rock when the pieces are cemented or compressed by the pressure of more sediments being piled on. This continuous activity is called the rock cycle. It has operated through most of Earth's history.

On the diagram on the next page, write the appropriate rock name on the blank lines and sketch the texture of each rock in the boxes. In the space below the diagram, write the names of the kinds of rocks you have identified.

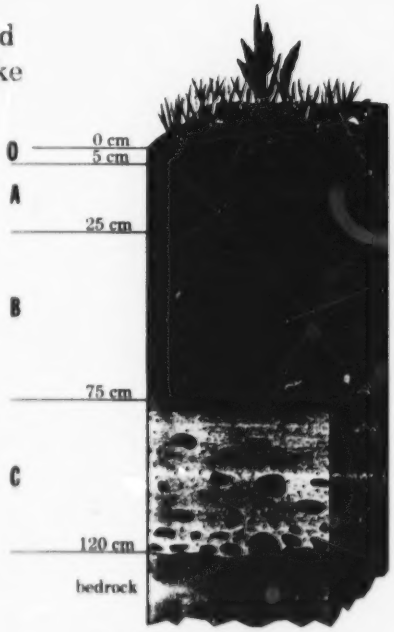
The Rock Cycle



Where Does Our Soil Come From?

Soil development is a complex interaction of rocks and minerals (land), water, air, and living things. Over tens to thousands to hundreds of thousands of years, the parent material—sediment, bedrock, or soil transported from elsewhere—is changed into a layered mixture of organic and mineral matter called **soil**. The layers are called **horizons**, and the set of horizons in a soil is called its **profile**.

Weathering of the parent material breaks up rock and sediment on Earth's surface. Weathering processes make new minerals and particle sizes. Over a long time, changes can reach tens of meters below the surface. The depth and character of a soil profile is different from place to place, depending on how long weathering has operated, how steep the surface is, the kind of climate, and the texture and composition of parent material.



Profile of a good agricultural soil. O, A, B, and C are soil horizons.

Different soils have been given different names.

The numbers of living things in most soils are hard to imagine. In about ten cubic centimeters of soil live about 7 billion bacteria, 1 million fungi, 100,000 algae, 3 million actinomycetes, and 4 to 5 million protozoa. (From "Life in a Teaspoon of Soil," by Shirley Foster Fields, *Science Scope*, *16* (5), February 1993, pp. 16-18.) Most microscopic organisms live in the upper soil layers where they convert dead organic matter into plant food, form acids that help dissolve rocks and minerals, and move constantly to keep soil loose and crumbly.

Larger creatures like worms and moles move soil sediments around. They make holes that aid the movement of gases and water. Dead plants and animals contribute humus and humic acids, which condition the soil and aid in weathering the inorganic rocks and minerals.

Air can penetrate the space between soil particles. Surface water filters down toward the water table. Soil gases from photosynthesis, respiration, and decomposition of organisms move up toward the surface.

Downward-moving water (infiltration) carries dissolved minerals and small solid sediments like clay and silt into

the "B" horizon. Erosion at the top of the soil carries away varying amounts of the "A" horizon. Upward-moving water (capillary migration) carries dissolved minerals and water from lower to upper horizons.

Activity: Capillary Migration

You can demonstrate capillary migration by placing in a tray of water a brick, the ends of paper towels hung from a stick or hanger, and a meter or so of clear plastic tubing filled with soil. Observe the movement of water over a few days. Ask students to compare and contrast the textures of the three materials and to suggest reasons for the differences they see. Add a big piece of loosely cemented sandstone to the experiment if you have one.

Activity: Soil in the Window Scene

Ask students to describe the soil from the window scene, or from another appropriate place. Different climates and parent materials produce different soils. Add soil to the big chart.

Have students research the local soils to learn their composition and the original location of the soil resource. For example, many soils in the north-central United States are on sediment transported by glacier from Canada. Some soils in the Great Plains and Mississippi Valley are on material blown by wind. (From what direction does the wind blow in the contiguous United States? See diagram of global wind belts in the Air unit.)

Students may enjoy learning about soil names, as an extension.

Extension: Soil Analysis

You may wish to have students test the pH and other properties of soil samples, like moisture and organic content, mineral materials, and porosity (amount of space). Use samples collected from the window scene or from home or other place. (Instructions and safety notes for working with acids and bases and the pH scale, for rating the acidity or alkalinity of a substance, are in the Air unit.) Soil-testing methods are good activities for learning laboratory and mathematical skills.

Suggested Resources

• Eswaran, Hari, Kupelian, Ted, Levermann, Tom, and Yost, David. (1990, May). The Science of Soil. *The Science Teacher, 57* (5), 50-53.

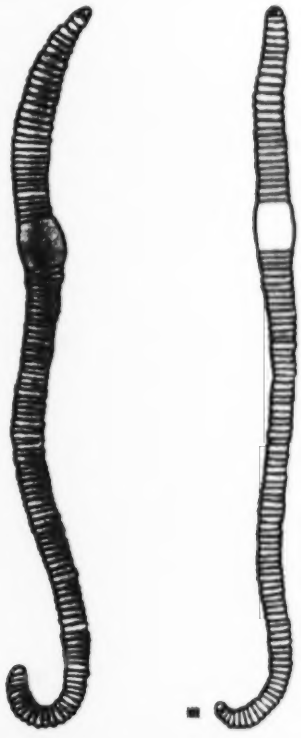
• Kennedy, Ann C., Smith, Karen L., and Neff, Raymond L. (1995, February). Soil Searching. *The Science Teacher, 62* (2), 34-38.

Extension: Lichens and Weathering

Lichens are plants that grow in rocky places in almost every climate. They help start the formation of soil. In lichens, fungi and blue-green or green algae share living space. Algae make food, fungi furnish a sheltering environment. Students may research the symbiotic living arrangement and food web of lichens.

Activity: Soil

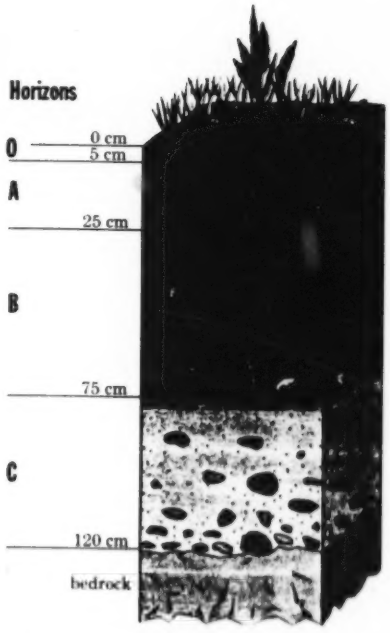
Hand out the Activity Sheet "A Soil Profile and Soil Ecosystem" and show the transparencies of the soil profile and soil ecosystem. You may use the questions as a discussion guide or have students write their answers. Ask students to recall the food webs they constructed in the Life unit before they diagram the web in the soil ecosystem. Students may need to research eating habits of the organisms pictured in the soil ecosystem.



Two earthworms common in agricultural soil (at full scale). They are about the same size, but *Lumbricus terrestris*, on the left, is red and *Allolobophora caliginosa*, on the right, is pink. Their girdles are in slightly different locations with respect to their segments (the numbers).

A Soil Profile and Soil Ecosystem

Soil is one of our most important resources. Humans rely on good agricultural soil for growing food. These diagrams are from the transparencies your teacher will show. Use the pictures to answer the following questions.



A Soil Profile.

A Soil Ecosystem.

Questions

1. In which parts of the profile do most organisms live?
2. Where does erosion occur?
3. How deep has weathering reached?
4. Where does surface water go when it falls on this soil?
5. Where does capillary migration of water occur?
6. Where would groundwater be?
7. Where would the water table be? What might determine the depth from the surface to the water table?

The Soil Food Web

Make a diagram to show the food web illustrated in the picture of the soil ecosystem.

How Do People Use Land?

The last question in this unit can be read two ways. What do we use land for? and, How do we treat land when we use it? These questions are starting to govern how people view future land use. A good resource is the December 1988 issue (Vol. 174, No. 6) of *National Geographic*, "Can Man Save This Fragile Planet?"

What Do We Use Land For?

Students may answer this question by naming homes and buildings, roads, farming, ranching, mining, forests, parks, or other activities they are familiar with. The term "land use" applies to this question and, in a library search, leads to material about planning and zoning. Students in Oregon will find references to the statewide zoning laws, for example.

Activity: Land Use

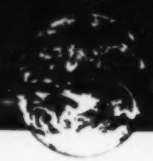
Ask students what the land in the window scene is used for. Find out about your community's planning and zoning regulations. How is land in the window scene zoned? Have students add the land-use and zoning information to their landscape descriptions.

How Do We Treat Land When We Use It?

The second question is harder to answer. Is leaving corn stubble in a field a "better" or "worse" treatment than plowing a field? Is managing forest land for harvesting trees "better" or "worse" than leaving forest land as wilderness? What kind of treatment is building houses on former farm land, or mining land for kaolin, coal, salt, or iron and other metals? How can people compare different ways of treating land?

Suggested Resource

Ramse;y, John M., Hungerford, Harold R., and Volk, Trudi L. (1990, March.) Analyzing the Issues of STS [Science, Technology, Society]. *The Science Teacher, 57* (3), 60-63.



Activity: Different Ways of Farming

Ask your U.S. Department of Agriculture county agent to tell the class about "best agricultural practices" for your part of the country. Take a field trip to see BAPs being used.

Resource Extraction and Land Reclamation

People have learned that disturbing land to extract resources like coal or kaolin has economic benefits—coal to burn to generate electricity and kaolin clay for making paper. People have also learned that leaving land in a disturbed state can bring on an economic loss. Sediment eroded from rubble piles may clog streams and damage drinking water supplies. Chemicals like sulfur compound in the rocks dissolve in runoff and enter streams and groundwater, making the water acid. (Acid water draining from abandoned coal mines is a problem in some states.)

People in the United States have decided that they want land reclaimed after disturbance and have passed laws requiring reclamation. Successful reclamation takes a long time and large amounts of money. For example, restoration on the surface coal mine in Illinois pictured on the cover of this unit will take 8 to 10 years and cost $12,000 to $20,000 per hectare ($30,000 to $50,000 an acre). The land surface will be graded to the original slope and topsoil, which was saved when the mine was opened, will be replaced. Crops to retain topsoil and rebuild soil fertility will be planted. The result will be good farm land. A nearby surface mine was restored to wetlands, which had occupied the area before it was drained for farming.

Activity: Resources in Window Scene Materials

Ask students to find out how land was treated to extract the resources used in human-processed materials in the window scene. Examples of resources are sand and gravel for construction, quartz sandstone for glass, limestone for cement, crude oil for plastics, copper, tin, and zinc, which is used in dry-cell batteries. (Students have already researched the locations of the resources.)

Have students make a new column, Resource Extraction, on the big chart and record this information.

Activity: The Cover Picture

The dragline in the picture burns fuel to dig coal. The coal goes to a nearby power plant, which burns it to make electricity. Ask students to describe the steps in creation of the dragline, and to show where electricity produced from the coal might be used in that process.

Energy Use and Resources

Extracting natural resources requires energy. So does making materials from these resources. Today people produce energy mainly from natural gas, oil, and coal. Burning these fossil fuels has added to the amount of carbon dioxide in air and created acid rain. Explore with students the benefits and costs of using fossil fuels. As an extension, study how fossil fuels formed and why they are called nonrenewable resources. (You will study renewable resources in the People unit.)

Suggested Resources

• Hubbard, Harold M. (1991, April). The Real Cost of Energy. *Scientific American, 264* (4), 36-42.
• [National Energy Foundation]. (1993, October). Petroleum Exploration and Production. *Science Scope, 17* (2), 32-33.
• Repetto, Robert. (1992, June). Accounting for Environmental Assets. Scientific American, 266 (6), 94-100.
• Shewell, John A. (1994, January). Teaching about Natural Gas and the Environment. Science Scope, 17 (4), 28-29.
• Shewell, John A. (1995, February). Technology and "Buried Sunshine" [coal]. Science Scope, 18 (5), 35-36.

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